Darrell Schult

HISTORICAL FIRE REGIMES ON THE BEAVERHEAD-DEERLODGE NATIONAL FOREST, MONTANA

-BEAVERHEAD PORTION-

FINAL REPORT
CONTRACT NO. 43-0356-6-0107

June 1997

Stephen W. Barrett
Research Forester

INTRODUCTION

Fire history databases are important for ecologically-based forest management, as recognized in the recent Interior Columbia Basin Ecosystem Management Project (ICBEMP)(Quigley et al. 1996). Scientists and natural resource policy makers recognize that presettlement fire regimes can help guide management of multiple use lands and natural areas, such as wilderness and national parks (Kilgore 1981, Arno and Brown 1989, Mutch 1994, Mutch et al. 1994). For example, fire history can serve as a critical baseline reference for ecosystem monitoring and restoration, fuels management silviculture, prescribed fire planning, and other activities.

Many vegetation types show wide variation in presettlement fire patterns, and show varying degrees of impact from attempted fire exclusion. Although fire regimes models are useful in some contexts (Quigley et al. 1996), models cannot describe actual site fire history or quantify the effects of fire exclusion for all localities. Furthermore, management controversies are often exacerbated in the absence of local information. The value of site-specific data is apparent when examining the results of studies in lodgepole pine (*Pinus contorta*) forests (Arno 1980, Romme 1979, Romme and Despain 1989, Barrett et al. 1991, Barrett 1993a, Barrett 1993b, Barrett 1994a, Barrett 1996, Barrett 1997). Lodgepole pine is a major subalpine forest type in the Northern Rockies showing widely varying presettlement fire regimes. On relatively dry sites, mixed severity fires often occurred after short to moderately long intervals (25-100 yr)(Arno 1976, Sneck 1977, Barrett et al. 1991, Barrett 1997). Conversely, long-interval (150-300 yr) stand replacing fires have occurred on moist- and/or cold sites, such as in Yellowstone- and Glacier National Parks (Romme 1979, Barrett et al. 1991, Barrett 1994a, Barrett 1997).

Previously, only limited fire history data were available from cold-dry forests dominated by lodgepole pine and Douglas-fir (*Pseudotsuga menziesii*) in southwestern Montana (Pierce 1982, Arno and Gruell 1983, Arno and Gruell 1986, Bakeman 1983). Accordingly, this report presents the results of extensive sampling conducted on the Beaverhead portion of the Beaverhead-Deerlodge National Forest between 1992 and 1996.

METHODS

Fire history sampling was conducted by establishing transects and representative plots (Arno and Sneck 1977) in the various habitat type fire groups on the Forest (Fischer and Clayton 1983). Agency field crews sampled numerous plots between 1992 and 1994, then the raw data were forwarded to this author for analysis. To supplement the database and check the representativeness of agency-collected data, I conducted further reconnaissance sampling in 1996. Ultimately the agency data accounted for about 75 percent of the total database, and my sampling produced the remainder.

Besides conducting most of the sampling, agency personnel provided the first-generation analysis of their data (i.e., laboratory preparation and tree ring counts). I produced the final analysis by first examining a subset of the agency's fire scar cross-sections to insure that scars had been correctly diagnosed and dated. To interpret fire history, I adjusted the fire year estimates from clustered plots to produce drainage- and stand master fire chronologies (Arno and Sneck 1977, Romme 1980, Arno and Peterson 1983). Drainage fire frequency was assessed by calculating mean fire intervals (MFIs), which are estimated by dividing the total number of years in the area chronology by the number of fire intervals. Site fire chronologies were also

used to calculate MFIs for the stand level of analysis (Arno and Peterson 1983) when the data produced two or more fire intervals. When the stands lacked fire scars but had evidence of two or more fire-initiated age classes, stand age class chronologies were developed by estimating the number of years between successive fires (Barrett and Arno 1988, Brown et al. 1994). Then a multiple-site average fire interval (MAFI)(Barrett and Arno 1988) was calculated by totaling the individual fire intervals from ecologically similar stands and dividing by the number of fire intervals.

An approximately 10,000 acre study area (i.e., Lacy Creek drainage) also was sampled with sufficient intensity to produce a forest age class map (Heinselman 1973, Barrett et al. 1991, Barrett 1993, Barrett 1994a, Barrett 1996, Barrett 1997). By displaying actual fire history, such maps are useful for interpreting landscape fire patterns and the mix of area fire regimes (map included with this report; on file, Beaverhead-Deerlodge National Forest).

RESULTS AND DISCUSSION

A total of 256 fire scar cross-sections and numerous age class cores produced fire history information from 15 drainages and 85 sample stands. Representative data were obtained from all major forest types and fire groups (figs. 1-2). Most (60%) of the samples were obtained from the lower subalpine zone in Fire Group Seven (i.e., cool habitat types dominated by lodgepole pine), and the rest were from the montane- and upper subalpine zones (28% and 12%, respectively). This sampling is considered representative because the proportional breakdown approximates that for forest zonation in southwestern Montana. Although my sampling produced more variation in fire frequency- and severity patterns than the agency sampling, the

overall results generally agree.

Landscape Fire History. Coarse-scale fire frequency was estimated for 15 representative drainages on the Beaverhead (table 1; fig. 3). The analysis areas range in size from about three- to ten thousand acres each, and all of the drainages displayed robust fire histories before the late 1800s. Most drainage MFIs ranged from 15 to 30 years long (mean MFI: 32 yr), and the maximum fire-free intervals usually were less than 50 years long in any given area (table 1; fig. 3). Age class maps provide another indicator of a highly active presettlement fire history. Repeated fires after short-intervals made age class mapping difficult for both the Lacy Creek study area, and for Murray's (1996) three study areas in the West Big Hole Mountains. That is, frequent mixed severity fires had produced small- to moderate size (i.e., <1000 ac) polygons, often with ill-defined stand margins. Stand replacing runs also were usually less than 1000 acres each, and comprised only 12 percent of the mapped polygons in Murray's (1996) study areas. The latter finding is similar to my results, in that only 18 percent of the sample stands were considered to occur in the stand replacement fire regime (discussed below).

In terms of regional fire history, the database and results from past studies reveal a number of historic fire years or episodes in southwestern Montana. Many trees sampled by agency crews recorded fires in circa 1846, and my subsequent sampling in the Lacy Creek drainage also suggested a major fire during that year. A severe drought apparently occurred during that year (Graumlich 1987), which was also the last important fire year in Arno and Gruell's (1986) Galena Gulch study area on the Deerlodge portion of the Forest. In the West Big Hole Mountains, Murray (1996) found that 40 percent of his study area had burned in the 39 years between 1834 and 1873. Moreover, fire atlas data (on file, Beaverhead-Deerlodge N.F.)

suggest that nearly 50,000 acres burned on the Forest in 1872, and about 62,000 acres burned in 1879. Finally, many samples had fire scars dating to 1889, and the fire atlas suggests that at least 77,000 acres burned during that year. (Because underburned areas typically are not shown on old fire maps, the acreage estimates are undoubtedly conservative). The historic 1889 fire year evidently was the most severe drought- and fire year in the Pacific Northwest during the last three centuries (Graumlich 1987, Barrett et al. [in press]).

Studies have shown that some of the Northwest's worst droughts and severe fire years occurred between the late 1800s and mid-1930s, following the end of the cool-moist Little Ice Age (Barrett et al. [in press]). Yet, despite the increasing fire potential, the fire scar data, results from other studies (Pierce 1982, Arno and Gruell 1983, Bakeman 1983, Arno and Gruell 1986, Murray 1996), and the fire atlas all indicate that regional fire frequency declined sharply after the late 1800s. For example, today's fire intervals are substantially longer than the presettlement MFIs in all 15 drainages (table 1; fig. 3). Two-thirds of the areas have not had a fire in 100 years or more, and the fire-free interval for all areas combined averages 3.5 times longer than the mean MFI (table 1). The Schultz Creek drainage provides the most compelling example: the sample trees produced a 38-year MFI between 1673 and 1823, but have not recorded a fire for the past 173 years. This suggests that the drainage was already experiencing a relatively long fire-free interval (i.e., ~50 yr) by the start of the settlement period.

Results from the Lacy Creek drainage provide another measure of disrupted fire cycles. Fire cycle is the time required to burn an area equal in size to the entire study area (Romme 1980). Fire cycle for the 10,000 acre sample area was about 81 years between 1686 and 1900, yielding an average of 124 burned acres per year. Fires continuing at that rate theoretically

would have burned about 12,000 acres between 1900 and 1996, or 120 percent of the total area. That is, some stands would have burned more than once during the fire exclusion period, while other areas would not have burned. In reality, however, only 46 acres have burned since 1900. The average of one half-acre burned per year thus computes to a 20,000 year fire cycle for the 20th century to date, a virtually one hundred percent reduction in area burned. Similarly, Murray (1996) found that post-1874 burned acres declined by 87 percent in the West Big Hole Mountains, and fire frequency declined by a factor of seven.

The results for the post-settlement period represent one of the most long-term and sharpest declines in fire frequency for any region of the Northwest (Heyerdahl and Agee 1994, Barrett 1995a). A few noteworthy fire years have occurred on the Beaverhead since 1900 (e.g., 1904, 1910, 1974, 1988), but only 70,000 acres have burned Forest-wide over the past 96 years. This yields an average of 729 acres burned per year on the 2.2-million acre Forest, or .0003 percent of the total area annually. However, a mean of between 30,000 and 48,000 acres (1.5% to 2%) of the Forest burned per year before 1900, based on conservative estimates from the Lacy Creek study area, or, on more liberal estimates derived from the total database (i.e., composite MFI from proportional representation in each Fire Group [tables 2-7; fig. 3]). Burned area has thus diminished by an estimated 98 to 99 percent since 1900. Moreover, post-1900 fire cycle for the entire Forest is about 3000 years, as opposed to 45 to 70 years during the presettlement era. As for potential causes, historical records (Smith 1973) suggest that as many as 150,000 livestock were grazing on the adjacent Salmon National Forest in 1918, and government officials had been actively promoting heavy grazing as an effective way to reduce spreading fires. Subsequently, area fire cycles were further disrupted by increasingly widespread agriculture and

effective fire suppression by the mid-1930s.

Stand Fire Regimes. The fire history data also were analyzed at the stand scale (Arno and Peterson 1983) to determine presettlement fire regimes for the various fire groups. These data are useful for modeling stand successional trends, identifying potentially shifting fire regimes, and planning for fuels management silviculture and prescribed fire (Arno and Brown 1989, Mutch 1994, Mutch et al. 1994, Quigley et al. 1996). Fire history data can also identify individual stands and drainages with the most seriously disrupted fire cycles, which is useful for scheduling and prioritizing management activities.

The data and results from other fire history studies (Pierce 1982, Arno and Gruell 1983, Bakeman 1983, Arno and Gruell 1986, Murray 1996) indicate that sublethal (i.e., nonlethal and mixed severity) fire regimes predominated during the presettlement era (figs. 4-6). Evidence of a mixed severity fire regime was found in two-thirds of the 85 sample stands, and nearly 90 percent had either a mixed- or nonlethal fire regime. Presettlement fire intervals ranged from short to moderately long, but nearly 75 percent of the stands had MFIs that were less than 50 years long (fig. 5). Although mixed severity fires occurred in all major fire groups, the lower subalpine zone contained the largest proportion of this fire regime (fig. 7). Stand replacing runs occasionally occurred on steep (e.g., >60%) north-facing aspects at mid- to upper elevations, but were usually limited in extent (Murray 1996). Most stand replacement intervals were relatively short, ranging from about 75 to 125 years long, and only 3 percent of the 85 sample stands had MFIs more than 100 years long. The Lacy Creek fire map and those for several drainages in the West Big Holes (Murray 1996) verify that small- to moderate size (i.e., <1000 ac) mixed severity

fires were commonplace before 1900.

In comparison with presettlement fire regimes in adjacent western Montana (Quigley et al. 1996), the Beaverhead evidently had about half as much terrain in the nonlethal fire regime, and 25 percent more terrain in the mixed severity regime (fig. 6). This may be attributable to the predominance of cold, dry lodgepole pine stands in southwestern Montana, which are less fire resistant than warm, dry ponderosa pine (*Pinus ponderosa*) stands, and more conducive to mixed severity fires because of highly variable fuels. Otherwise, the percentage of terrain in the presettlement stand replacement regime evidently was similar for both regions. Also note that Murray's (1996) more liberal definition of non-lethal fire resulted in his classifying 60 percent more terrain in that category than suggested by my database (i.e., 76% vs. 15% respectively). In the West Big Holes, Murray (1996) assigned nonlethal severity to small plots in which more than one tree per acre had survived a given fire, whereas I used the ICBEMP definition specifying a greater than 90 percent survival rate at the stand level (Morgan et al.[in press]). However, our estimates for proportion of terrain in the stand replacement regime agree (i.e., 18% vs. 19%, respectively), and Murray (1996) found that such fires have more than doubled in frequency and size during the post-settlement period. Similarly, ICBEMP results for western Montana suggest that the percentage of terrain in the stand replacement regime has tripled since 1900.

The following information was obtained for presettlement fire regimes by fire group. Representative data were obtained from nine dry stands along lower timberline in the montane forest zone (Fire Group Five; table 2, figs. 1-2, 7). Old growth Douglas-firs in uneven age stands occasionally had more than 10 fire scars each, and the results suggest relatively short fire intervals between primarily nonlethal fires. About two-thirds of the stands displayed an overall

pattern of nonlethal fires, whereas the remaining third, typically on northerly aspects, suggested primarily mixed severity fires (fig. 7). Most fire intervals ranged from 15 to 85 years long, and the 9-stand average MFI was 37 years. MFIs on northerly aspects were 33 percent longer than on southerly aspects (i.e., 46 years vs. 31 years). To date, however, three sample stands have not experienced a fire in the last 130 to 145 years, and the current fire interval averages 105 years for all nine stands--nearly three times longer than the presettlement mean MFI (fig. 8). Also note that, because fast-moving grass fires do not always scar trees (Arno 1976), the presettlement fire frequencies for Fire Group Five are likely conservative estimates, particularly for any previously open south-facing stands (fig. 9).

Data were obtained from 15 relatively moist stands dominated by Douglas-fir and lodgepole pine in the montane forest zone (Fire Group Six). Results suggest that mixed severity- and nonlethal fires were common before ca.1900 (table 3, fig. 7). Fire frequencies were similar to those for Fire Group Five, that is, the fire intervals ranged from about 15 to 60 years long, and the 15-stand mean MFI was 32 years. (Similar MFIs may have resulted because estimates for dry sites in Fire Group Five are likely conservative). The current stand fire intervals range from 88 to 150 years long, and the 15-stand mean is 123 years, which is nearly four times longer than the presettlement mean (fig. 8). This factor, coupled with the inherently heavier fuels on moist sites, has substantially increased the risk of stand replacing fires. Overall, these results for montane stands in Fire Groups Five and Six are comparable to those generated by previous studies (Houston 1973, Loope and Gruell 1973, Pierce 1982, Arno and Gruell 1983, Arno and Gruell 1986, Barrett 1994a, Barrett 1994b).

Lower subalpine stands dominated by lodgepole pine are the major forest type on the

Beaverhead, and comprise the bulk of the database. Specifically, about 60 percent of the data occur in Fire Groups Seven, Eight, and Nine (figs. 1-2, figs. 7-8). Results were obtained from 40 stands in Fire Group Seven (table 4), and fire frequencies and severities ranged widely in this group. For example, about 70 percent of the stands had evidence of mixed severity fires, that is, fires generating multiple seral age classes in the stand. About 25 percent produced data for stand replacing fires, and these single-age stands usually occur on steep northerly aspects. Only about 5 percent of the stands had evidence of nonlethal fires (i.e., fires that failed to initiate multiple stand age classes). The stand MFIs also ranged widely, from about 15 to 110 years long (40-stand mean: 46 yr). Although presettlement fires were relatively frequent in Fire Group Seven, the current fire interval averages 125 years long and is from two to four times longer than most presettlement MFIs.

Results were similar for Fire Groups Eight and Nine (tables 5-6, figs. 7-8), despite their differing environmental traits. Fire Group Eight is composed of dry lower subalpine stands dominated by Douglas-fir and/or lodgepole pine, whereas Group Nine contains moist lower subalpine stands with spruce (*Picea engelmannii*) as a major component. Samples from both groups suggested primarily mixed severity fires after short- to moderately long intervals (35-50 yr MFI) during the presettlement era. The lack of variation between these groups likely results from the fact that only three stands in Fire Group Nine yielded long-term data. However, stand replacement intervals ranging from 75 to 125 years long were occasionally found in adjacent stands on north aspects (Fire Group Seven), and probably can be extrapolated to similarly moist stands in Group Eight. The current fire intervals in Fire Groups Eight and Nine average between 115 and 120 years long, suggesting increased potential for stand replacing fires, particularly in

dense spruce-fir (*Abies lasiocarpa*) understories.

Ten stands produced data on presettlement fire regimes in the upper subalpine zone (Fire Group Ten; table 7; figs. 7-8). The sampled fire frequencies in stands dominated by lodgepole pine and/or whitebark pine (*Pinus albicaulis*) were longer than in most lower subalpine stands (e.g., 70 yr vs. <50 yr). Fire severities were also highly variable in the upper subalpine zone. About 60 percent of the stands had evidence of mixed severity fires, and the remainder produced data for stand replacing fires, typically on northerly aspects. However, the latter may be a somewhat liberal estimate because stand replacing fires might have destroyed evidence of previous sub-lethal fires on some sites. Nonetheless, previous studies (Romme 1979, Romme and Despain 1989, Barrett 1994a, Murray 1996) verify that presettlement fire intervals and severities were highly variable in this forest zone as result of the highly variable fuels. Overall, however, the data suggest that today's fire intervals are often more than twice as long as the presettlement MFIs (table 7).

Ecological Implications. These fire history results raise many implications for both landscape- and stand-scale management. At the stand scale, the overall lack of fire in this century has severely disrupted succession in Douglas-fir stands near lower timberline. Before the late 1800s, frequent ignitions by lightning and Indians maintained very open and lightly stocked stands along valley edges (fig. 9). Indians commonly ignited purposeful and accidental fires in valley grasslands and adjacent dry forests (Barrett and Arno 1982, Gruell 1985, Barrett and Arno [in prep]). For example, fires were useful for influencing game movements and rejeuvenating forage, game drives, clearing campsites and trails, communication, warfare, and entertainment.

A Blackfeet Indian recently told me about so-called "horseback lightning," that is, his ancestors regularly burned grasslands along the Rocky Mountain Front using transported embers. Because of fire's long-term absence, however, many Douglas-fir stands have thickened, especially on northerly aspects. The resultant fuel buildups have therefore increased fire severity potential, that is, a shift toward future mixed severity or stand replacing fires (Arno and Gruell 1983, Arno and Gruell 1986). Conifers have also successfully invaded grasslands, seral aspens (*Populus tremuloides*) have declined in vigor, and sagebrush (*Artemisia* spp.) now dominates many areas formerly occupied by grasses (Houston 1973, Loope and Gruell 1973, Pierce 1982, Arno and Gruell 1986, Barrett 1994b). Early photographs (Gruell 1983) verify that many areas in southwestern Montana previously had a greater mix of post-fire successional stages, including substantially more unforested terrain (fig. 9).

Fire exclusion has also reduced stand- and landscape diversity in subalpine forests. From a landscape perspective, the forest mosaic has aged more uniformly and is becoming less diverse spatially and compositionally (Romme and Knight 1982, Murray 1996). By prolonging the survival of most pine age classes in this century, fire exclusion has thus promoted increased stand decadence caused by pine beetles (*Dendroctonus ponderosae*), blister rust (*Chronartium ribicola*), root rots, and subsequent windfalls. For example, fire exclusion likely has exacerbated pine beetle epidemics in the region (Armour 1982, Barrett et al. 1991). Many stands that had a primarily mixed severity fire regime therefore might have shifted into the stand replacement fire regime during this century.

Long-term fire exclusion also threatens the perpetuation of fire dependant species such as whitebark pine. Long fire intervals promote development of highly flammable spruce-fir

understories, potentially reducing the longevity of old growth whitebark pines that served as long-term seed sources. Blister rust-caused mortality has been less extensive than elsewhere in Montana and northern Idaho (Murray 1996). However, larger pine beetle epidemics would promote increased whitebark pine mortality, as well as possibly more-extensive and more-severe wildfires. Ironically, such fires might further reduce biodiversity, by regenerating extensive acreages of young, single-age stands in areas that previously had heterogeneous mosaics (Barrett et al. 1991, Agee 1993, Murray 1996).

Fire has shaped Western landscapes for the past 10,000 years, but a century of settlement activities has seriously disrupted that crucial role (Arno 1980, Pyne 1982, Quigley et al. 1996). As a result, many ecosystems have changed visibly from the presettlement condition. In terms of restoration, fuels management silviculture and prescribed fires might help mitigate fuel hazards and help perpetuate fire-dependant communities. Otherwise, in view of shifting fire regimes and declining landscape diversity, it is unclear which ecosystems will retain their primeval character.

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Table 1. Fire history data from 15 drainage fire chronologies, Beaverhead-Deerlodge National Forest (place names reflect creeks or other prominent landmarks).

SAMPLE AREA	F. SCAR SAMP.[1]	MFC[2]	NO. FIRES	INTERVAL RANGE	MFI[3]	YRS. SINCE LAST FIRE[4]
SPRUCE	29	1737-1891	12	5-28	14	103
SAGINAW	22	1707-1863	13	6-24	13	131
RICHARDS-LITTLE MILK	19	1658-1906	12	8-48	23	88
CALIFORNIA-RAMSHORN	12	1661-1889	10	13-50	25	105
MEADOW	3	1782-1882	4	20-63	33	112
DOWNEY	1	1727-1947	16	5-36	15	47
WISCONSIN-INDIAN	2	1661-1873	4	51-95	71	121
NORTH-SOUTH MEADOW	15	1711-1918	14	9-39	16	76
SOUTH WILLOW	3	1733-1865	6	13-39	26	129
BEAR-PAPOOSE	10	1664-1899	13	9-56	20	95
MORGAN-CLIFF	8	1647-1893	12	7-54	22	101
BRYANT	9	1656-1889	4	43-98	78	105
TOWER	6	1676-1867	4	21-93	64	127
SCHULTZ	11	1673-1823	5	15-81	38	171
LACY	55	1686-1900	14	4-31	17	96
			RANGES:	4-98	13-78	47-171
			MEANS:	15-56	32	107

[1]Number of fire scar cross-sections.

[2]Master Fire Chronology.

[3]Area mean fire interval.

[4]As of 1994 (1996 for Lacy Cr.).

Table 2. Fire regimes and environmental data for 9 stands on dry sites in the montane forest zone (*Fire Group 5*), Beaverhead-Deerlodge National Forest.

Stand	C.T.[5]	H.T.[6]	Asp.[7]	Elev. ft.	MFC[8]	No. Fires	Intervl Range	MFI[9]	Last fire[10]	Severity Pattern[11]
11209003	DF	Psme/ Cage	NE*	7000	1562-1913	9	13-101	44	81	NL, MS
11206002	DF	Psme/ Syor	N*	6300	1703-1849	4	25-94	49	145	NL, MS
11209009	DF	Psme/ Feid	N*	6500	1770-1856	2	(86)	-	138	MS, (NL)
9322016	DF	Psme/ Caru	W	6700	1726-1889	9	9-33	20	105	NL
9322017	DF	Psme/ Feid	F/W	6800	1707-1913	8	14-57	29	81	NL
9322018	DF	Psme/ Feid	S	6700	1743-1926	7	14-47	31	68	NL
9322019	DF	Psme/ Arco	SE	6800	1610-1912	13	6-56	25	82	NL
70204001	DF	Psme/ Arco	N*	7300	1647-1877	6	7-69	46	117	MS, NL
Cliff 2	DF-LP	Psme/ Syor	E	6400	1771-1866	3	37-61	48	130	MS
						RANGES:	6-101	20-49	68-145	NL-MS
						MEANS:	16-84	37	105	
						Means by aspect:				
						Northerly:	15-88	46	120	
						Southerly:	11-48	26	84	

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[5]Cover type codes: DF (Douglas-fir), LP (lodgepole pine), WB (whitebark pine).

[6]Habitat type acronyms follow Pfister et al. (1977).

[7] * = northerly aspects; unmarked = southerly.

[8]Stand master fire chronology (pre-fire suppression era).

[9]Stand mean fire interval.

[10]Years since last fire as of 1994 (1996 for Cliff 2).

[11]*Severity code*: NL=nonlethal, MS=mixed severity, SR=stand replacing.

Table 3. Fire regimes and environmental data for 15 stands on moist sites in the montane forest zone (*Fire Group 6*), Beaverhead-Deerlodge National Forest.

Stand	C.T.	H.T.	Asp.	Elev. ft.	MFC	No. Fires	Intervl Range	MFI	Last fire, yrs	Severity Pattern
20403002	DF-LP	Psme/ Caru	S	7000	1737-1844	6	9-31	21	150	NL, MS
20403045 20403044	DF-LP	Psme/ Caru	SE	7100	1737-1891	11	7-27	15	103	NL, MS
23501004	DF-LP	Psme/ Caru	W	6300	1745-1856	6	9-37	22	139	NL, MS
34203037 34207022	DF-LP	Psme/ Caru	W*	7500	1658-1846	8	10-49	27	148	NL, MS
30107018	DF-LP	Psme/ Caru	S	7800	1658-1889	7	9-59	39	105	MS, NL
33702050	LP-DF	Psme/ Vaca	E	7600	1778-1874	5	11-51	24	120	MS, NL
9322102	LP-DF	Psme/ Caru	N*	7100	1697-1856	4	38-67	53	138	MS
74404043	DF-LP	Psme/ Syal	S	7400	1770-1882	7	9-32	19	112	NL, (MS)
73303299	DF	Psme/ Phma	W*	7000	1664-1874	7	13-66	35	120	MS, (NL)
73103210	LP	Psme/ Libo	NW *	6600	1696-1899	5	25-84	51	95	MS
70901023	DF	Psme/ Syal	S	6700	1801-1866	2	(65)	-	128	MS, (NL)
72901001	DF	Abla/ Caru	S	7800	1683-1874	5	16-84	48	120	MS
60603033	LP-DF	Psme/ Caru	NW *	7100	1770-1865	4	24-39	32	129	MS
30107021 30107022	LP-DF	Psme/ Caru	SE	7800	1658-1906	7	8-85	41	88	MS, (NL)
34207007	DF-LP	Psme/ Caru	W	7600	1658-1846	9	9-49	24	148	NL, MS
						RANGES:	**7-85**	**15-53**	**88-150**	**NL-MS**
						MEANS:	**14-54**	**32**	**123**	
						Means by aspect:				
						Northerly:	**22-61**	**40**	**126**	
						Southerly:	**10-51**	**28**	**135**	

Table 4. Fire regimes and environmental data for 40 lodgepole pine dominated stands on cool sites in the lower subalpine zone (*Fire Group 7*), Beaverhead-Deerlodge National Forest.

Stand	C.T.	H.T.	Asp.	Elev. ft.	MFC	No. Fires	Intervl Range	MFI	Last fire, yrs	Severity Pattern
20103010	LP	Abla/ Libo	W*	6300	1689-1918	6	11-75	46	76	MS
11502010	LP-WB	Abla/ Vasc	SW	8300	1663-1770	3	15-92	54	224	MS, SR
10907028	LP-DF	Psme/ Juco	SW	7800	1697-1781	2	(84)	-	213	MS, SR
34201052	LP	Abla/ Vasc	NE*	7800	1753-1863	2	(110)	-	131	MS, SR
10708014	LP	Psme/ Juco	N*	8100	1666-1781	2	(115)	-	213	MS, SR
14704007	LP	Pico/ Caru	W	7600	1792-1863	3	19-52	36	131	MS
14601002 14601003	LP	Abla/ Vasc	NW *	7800	1792-1889	4	19-52	32	105	MS
21008026	LP	Abla/ Vasc	E	6600	1746-1889	3	45-98	72	105	MS, SR
21006020	LP	Abla/ Vasc	W	7800	1656-1844	2	(188)	-	150	SR
20403025 20403023	LP	Abla/ Vasc	E	7600	1641-1933	6	48-77	58	61	MS, (SR)
23504054	LP	Abla/ Libo	N*	6200	1689-1889	5	41-48	50	105	MS, (SR)
34204009 34204050	LP	Abla/ Vasc	NE*	7800	1753-1863	3	49-61	55	131	MS, (SR)
30508038	LP	Abla/ Libo	NW *	7000	1743-1786	2	(43)	-	208	SR, (MS)

30302061	LP	Abla/ Libo	W*	7100	1786-1863	2	(76)	-	132	SR, (MS)
30107056 30107139	LP	Abla/ Vaca	SE	7800	1713-1889	5	10-72	44	105	MS
60604053 60601045	LP	Abla/ Vasc	NW *	8200	1770-1947	8	13-34	25	47	MS
60705011 60704012	LP	Abla/ Vasc	SW	7800	1782-1882	4	20-63	33	112	MS
60205033 60306018	LP-DF	Abla/ Vasc	NW *	7500	1661-1873	4	51-95	71	121	MS
60703049	LP-DF	Abla/ Cage	W	8000	1727-1947	16	5-36	15	47	NL
74301002	LP	Abla/ Vagl	E*	7700	1633-1918	9	9-39	37	76	MS
74302003	LP	Abla/ Vagl	N*	6800	1773-1882	7	8-53	18	112	MS
70905003	LP	Abla/ Vasc	SE	7600	1708-1816	5	19-34	27	178	MS
74204053	LP	Abla/ Vagl	E*	7000	1733-1948	8	8-55	31	46	MS
74404004	LP	Abla/ Vasc	SW	8000	1733-1855	3	53-69	61	139	MS, SR
72901067	LP	Abla/ Vagl	N*	8100	1683-1899	6	12-85	43	95	MS
72701031	LP-DF	Abla/ Vagl	N*	7100	1696-1899	6	9-57	41	95	MS
LACY 2	LP	Abla/ Vaca	N*	6600	1774-1889	5	8-42	29	107	MS
LACY 5	LP	Abla/ Vasc	S	6720	1774-1900	3	44-72	63	96	MS
LACY 16	LP	Abla/ Vasc	E	7000	1638-1834	3	50-166	111	142	MS, SR
LACY 26	LP-WB	Abla/ Xete	E	7620	1735-1873	4	28-63	46	123	MS
LACY 40	LP	Abla/ Vasc	SW	7100	1763-1846	3	35-48	42	150	MS
LACY 46	LP-WB	Abla/ Vasc	S	7760	1763-1854	2	91	-	142	SR

LACY 47	LP-WB	Àbla/ Vasc	SW	7820	1704-1854	2	150	-	142	SR
STAND-ARD 3	LP	Abla/ Vagl	N*	7500	1808-1866	2	58	-	130	MS
STAND-ARD 5	LP	Abla/ Vasc	N*	7400	1701-1808	2	107	-	188	SR
STAND-ARD 6	LP	Abla/ Vagl	E	7600	1701-1866	2	165	-	130	SR
STAND-ARD 7	LP	Abla/ Vasc	NE*	7560	1808-1904	2	96	-	92	SR
W. FORK MADIS.	LP-DF	Abla/ Vasc	N*	6180	1781-1866	2	85	-	130	SR
CLIFF 1	LP-DF	Abla/ Vagl	E	6900	1771-1889	2	118	-	107	SR
WADE	LP-DF	Abla/ Vagl	NE*	6500	1675-1866	2	191	-	130	SR
						RANGES:	**5-188**	**15-111**	**42-224**	**NL-SR**
						MEANS:	**25-65**	**46**	**125**	

Means by aspect:

Northerly:	**17-59**	**40**	**118**
Southerly:	**30-72**	**50**	**131**

Table 5. Fire regimes and environmental data for 8 stands on dry sites in the lower subalpine zone (*Fire Group 8*), Beaverhead-Deerlodge National Forest.

Stand	C.T.	H.T.	Asp.	Elev. ft.	MFC	No. Fires	Intervl Range	MFI	Last fire, yrs	Severity Pattern
11405036	LP	Abla/ Caru	N*	8100	1676-1867	4	21-93	57	127	MS
20702034	LP	Abla/ Caru	SW	6700	1846-1889	2	(43)	-	105	MS, SR
20702011	LP	Abla/ Caru	W	6500	1796-1889	4	21-50	31	105	MS
25008008	LP	Abla/ Caru	NW *	7800	1781-1846	2	(65)	-	148	MS, SR
20303033	LP	Abla/ Caru	NE*	7000	1641-1884	6	11-113	49	110	MS
20303021	LP	Abla/ Arco	N*	8200	1630-1889	4	20-128	86	105	MS, SR
30107022	LP	Abla/ Caru	NE*	7700	1713-1889	6	14-48	35	105	MS
72701038	LP	Abla/ Caru	S	6800	1768-1899	8	12-25	19	95	MS, NL
						RANGES:	**11-128**	**19-86**	**95-148**	**NL-SR**
						MEANS:	**17-76**	**47**	**113**	

Means by aspect:

Northerly:	**17-96**	**57**	**119**
Southerly:	**17-59**	**25**	**102**

Table 6. Fire regimes and environmental data for 3 stands on moist sites in the lower subalpine zone (*Fire Group 9*), Beaverhead-Deerlodge National Forest.

Stand	C.T.	H.T.	Asp.	Elev. ft.	MFC	No. Fires	Intervl Range	MFI	Last fire, yrs	Severity Pattern
34204028	LP	Abla/ Caca	NE*	7900	1762-1863	2	(102)	-	131	MS, SR
72106019	LP	Abla/ Mefe	NW *	7600	1708-1893	6	24-58	37	101	MS
74507008	LP	Abla/ Alsi	N*	6900	1733-1865	5	13-50	33	129	MS
						RANGES:	13-58	33-37	101-131	MS-SR
						MEANS:	19-54	35	120	

Means by aspect:

Northerly:	**19-54**	**35**	**120**
Southerly:		**(N.A.)**	

Table 7. Fire regimes and environmental data for 10 stands on cold-moist sites in the upper subalpine zone (*Fire Group 10*), Beaverhead-Deerlodge National Forest.

Stand	C.T.	H.T.	Asp.	Elev. ft.	MFC	No. Fires	Intervl Range	MFI	Last fire, yrs	Severity Pattern
11407001	WB	Pial hts	W	8700	1753-1867	3	21-93	57	127	MS, SR
31707011 31707015 31707016	LP-WB	Abla-Pial/Vasc	NE*	7700	1673-1823	5	15-81	38	171	MS, SR
74603003	WB	Pial-Abla	SE	9400	1733-1837	3	22-82	52	157	MS
60504021	LP-DF	Abla-Pial/Vasc	SW	8500	1680-1865	4	16-119	62	129	MS
LACY 10	LP-WB	Abla-Pial/Vasc	NE*	7450	1638-1854	2	216	-	142	SR
LACY 11	LP	Abla-Pial/Vasc	NE*	7520	1638-1885	3	31-142	124	111	SR, MS
LACY 15	WB	Abla-Pial/Vasc	N*	8200	1638-1804	2	166	-	192	SR
LACY 29	WB	Pial-Abla	NE*	8160	1638-1826	2	188	-	170	SR
LACY 37	LP	Abla/Luhi-Vasc	NW*	7950	1686-1854	3	56-112	84	142	MS, SR
LACY 50	LP	Abla/Luhi-Vasc	NE*	7680	1774-1846	2	72	-	150	SR
						RANGES:	15-119	38-124	111-192	MS-SR
						MEANS:	20-105	70	149	

Means by aspect:

Northerly:	**34-112**	**82**	**154**
Southerly:	**20-98**	**57**	**138**

Fig. 1. Percent of Sample Stands by Forest Zone (N=85 stds)

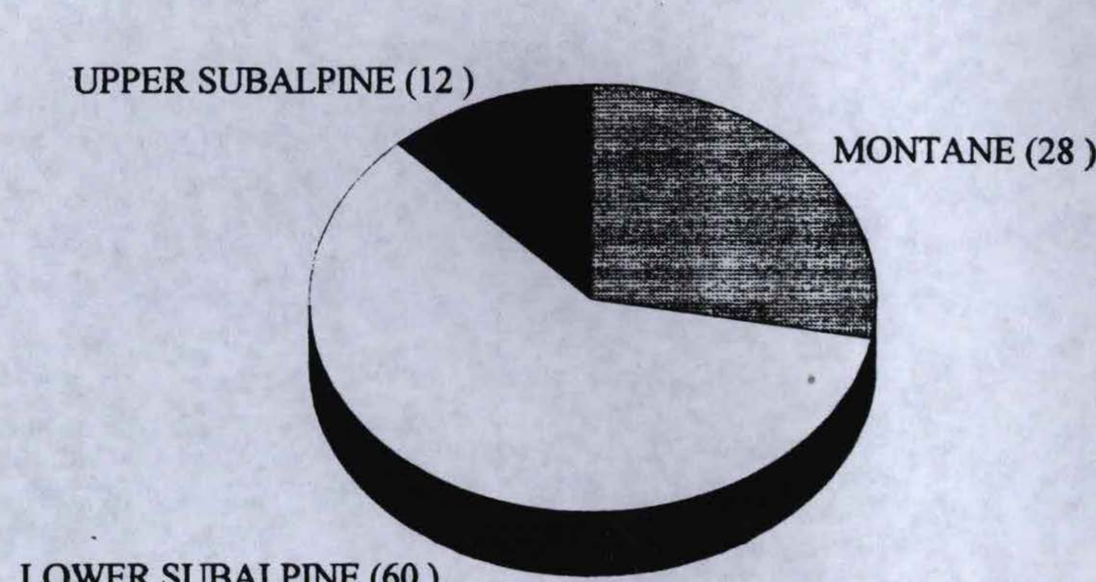


Fig. 2. Sample Stands by Fire Group
(N=85 stds)

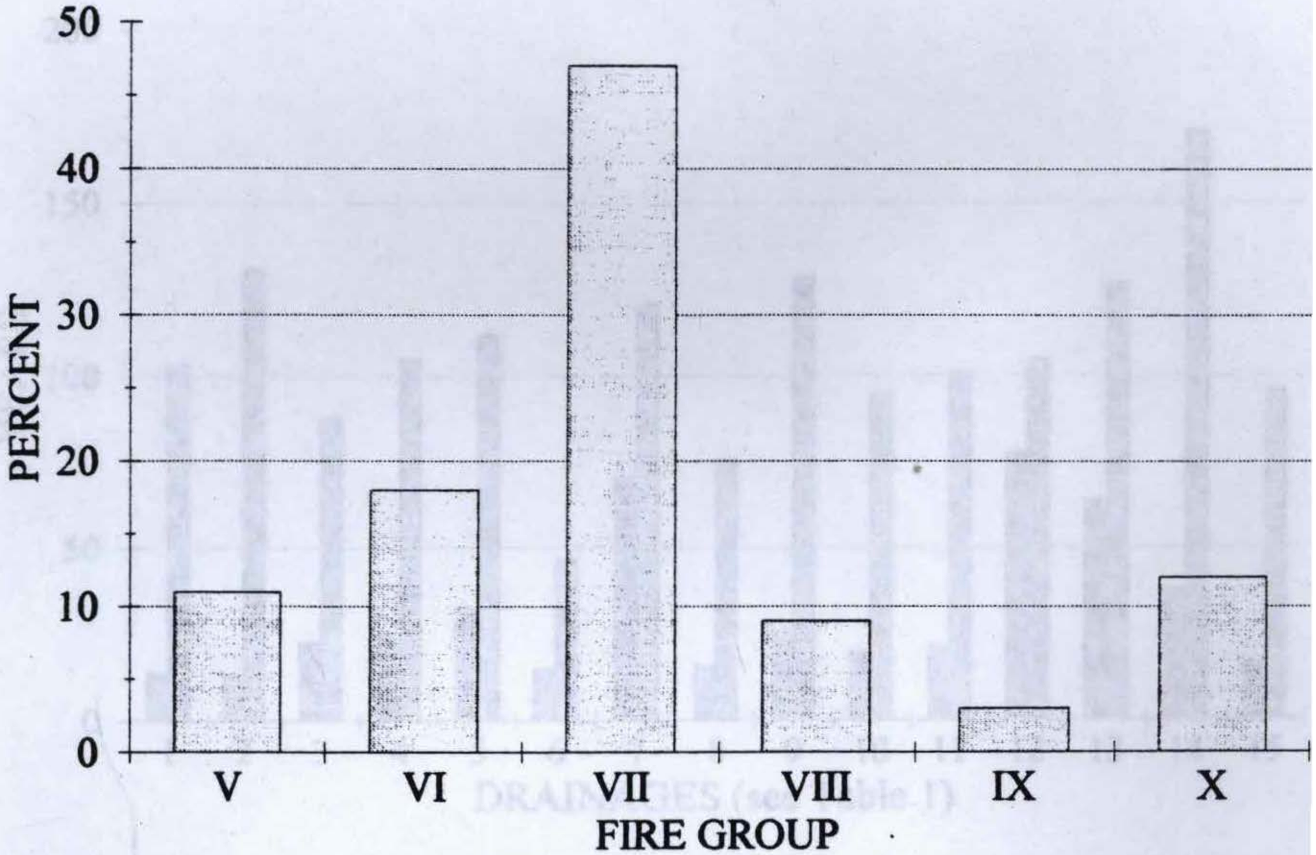


Fig. 3. Drainage MFIs vs. Years Since Last Fire

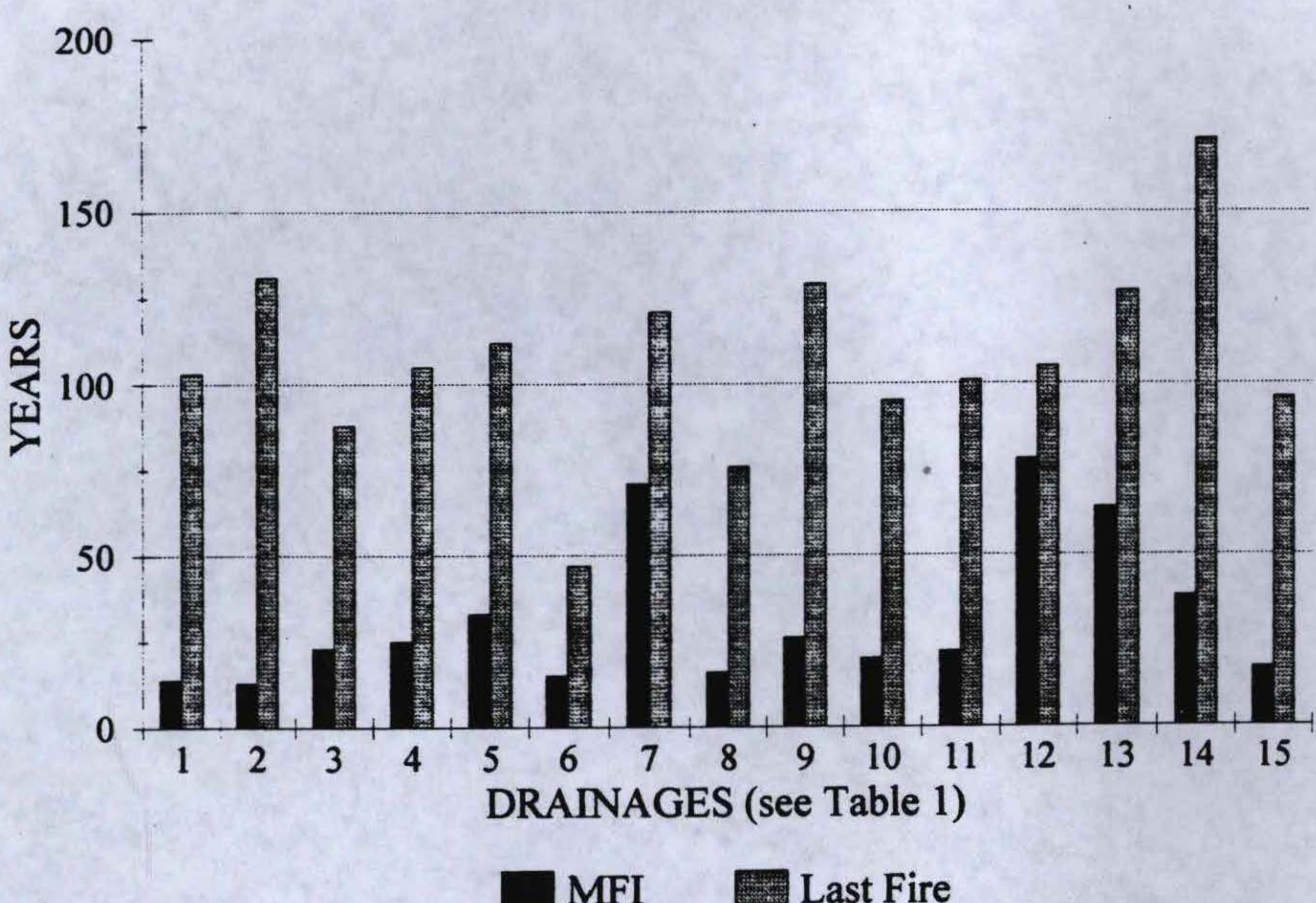


Fig. 4. Sample Stands by Fire Regime Type (N=85 stds)

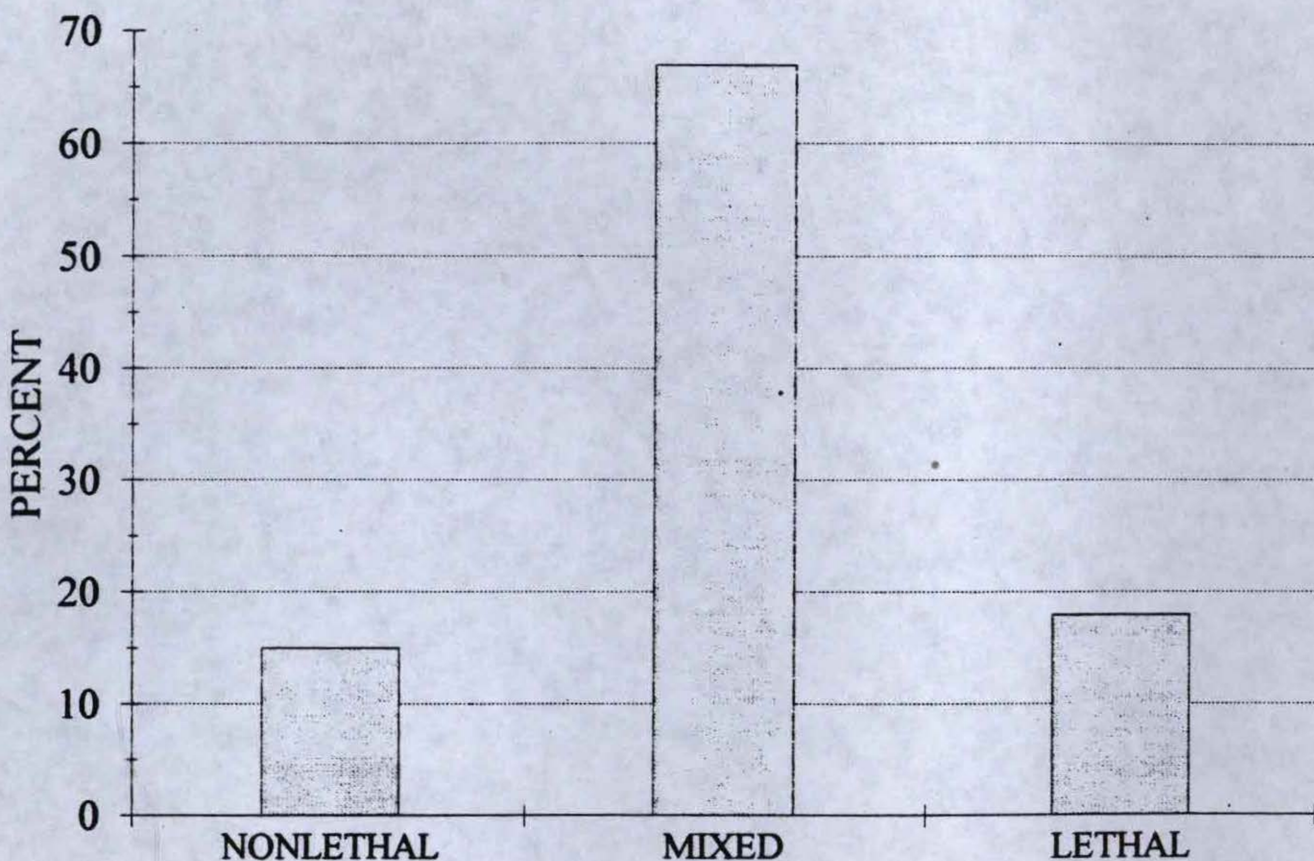
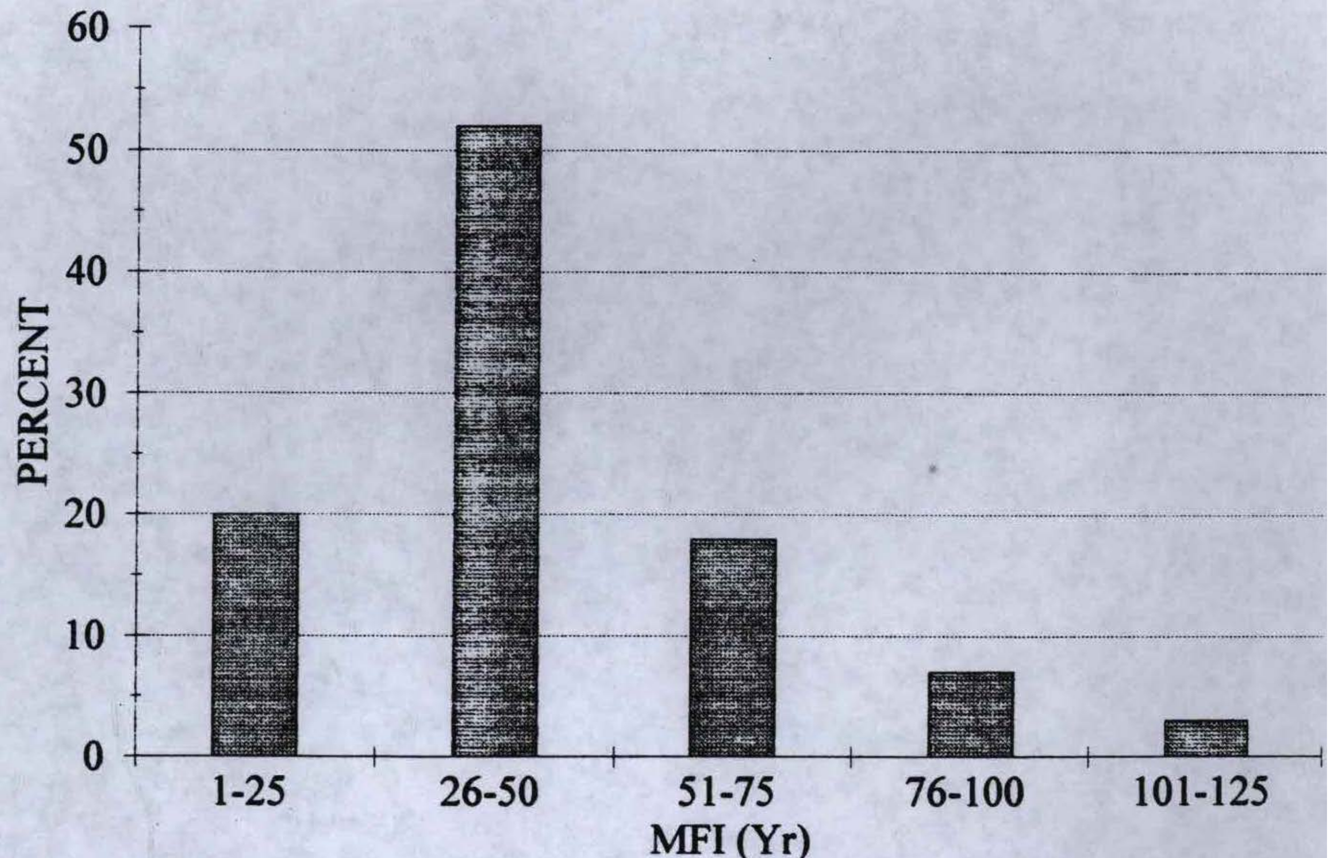


Fig. 5. Stands by MFI Class
(N=85 stds)



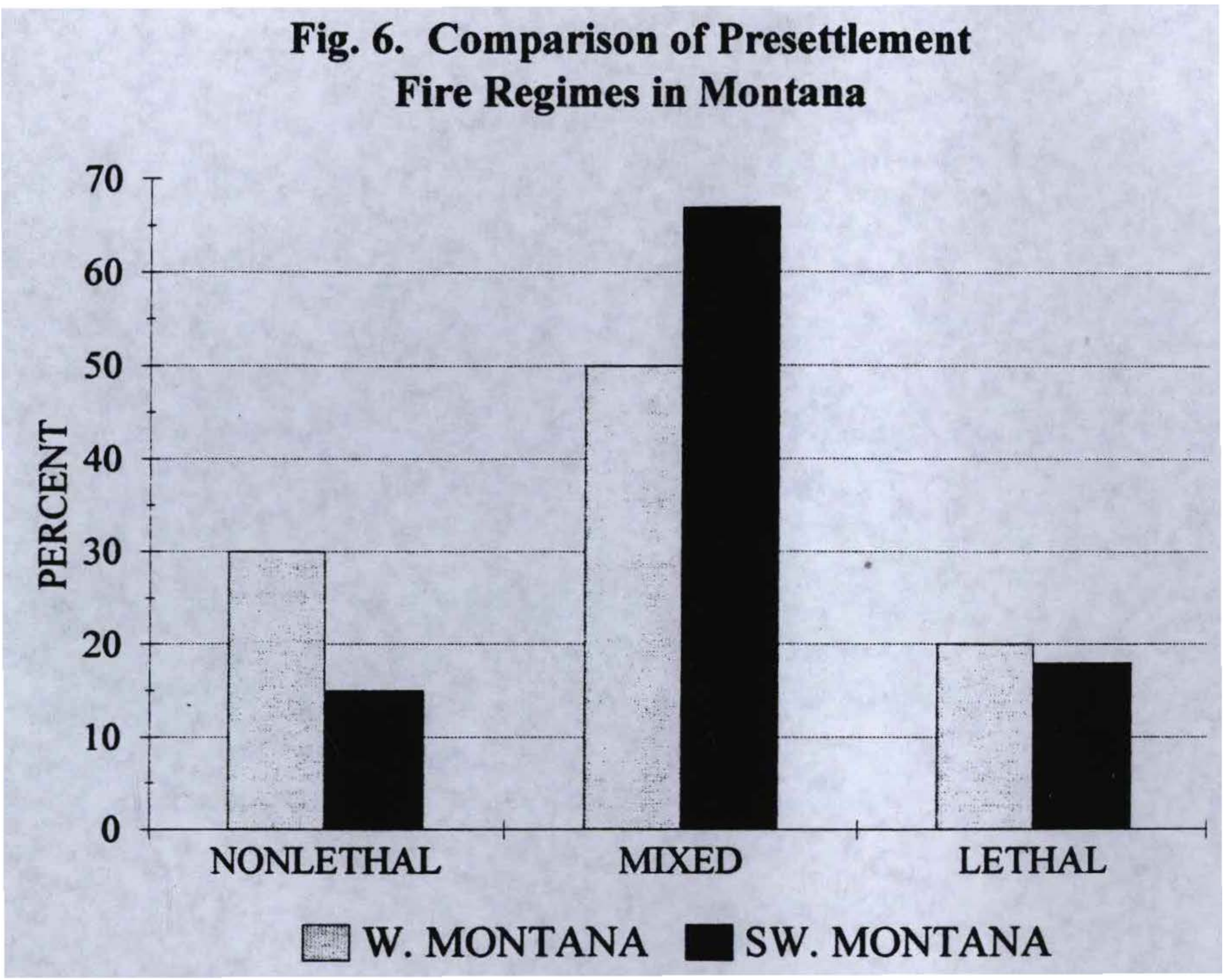


Fig. 6. Comparison of Presettlement
Fire Regimes in Montana
70
60
50
40
30
20
10
0
PERCENT
NONLETHAL
MIXED
LETHAL
W. MONTANA
SW. MONTANA

Fig. 7. Fire Severities by Fire Group
(N=85 stds)

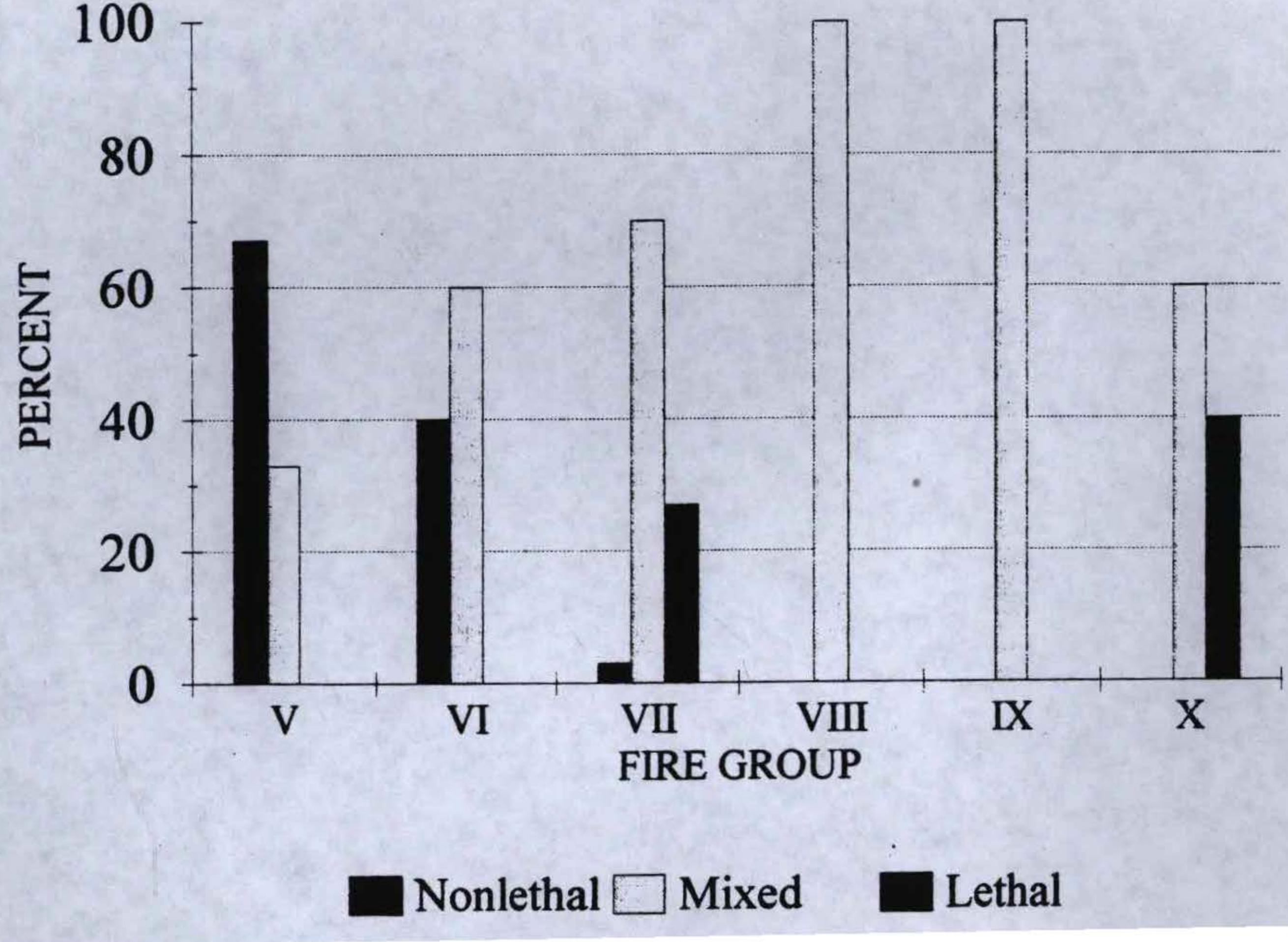


Fig. 8. MFIs vs. Years Since Last Fire by Fire Group (N=85 stds)

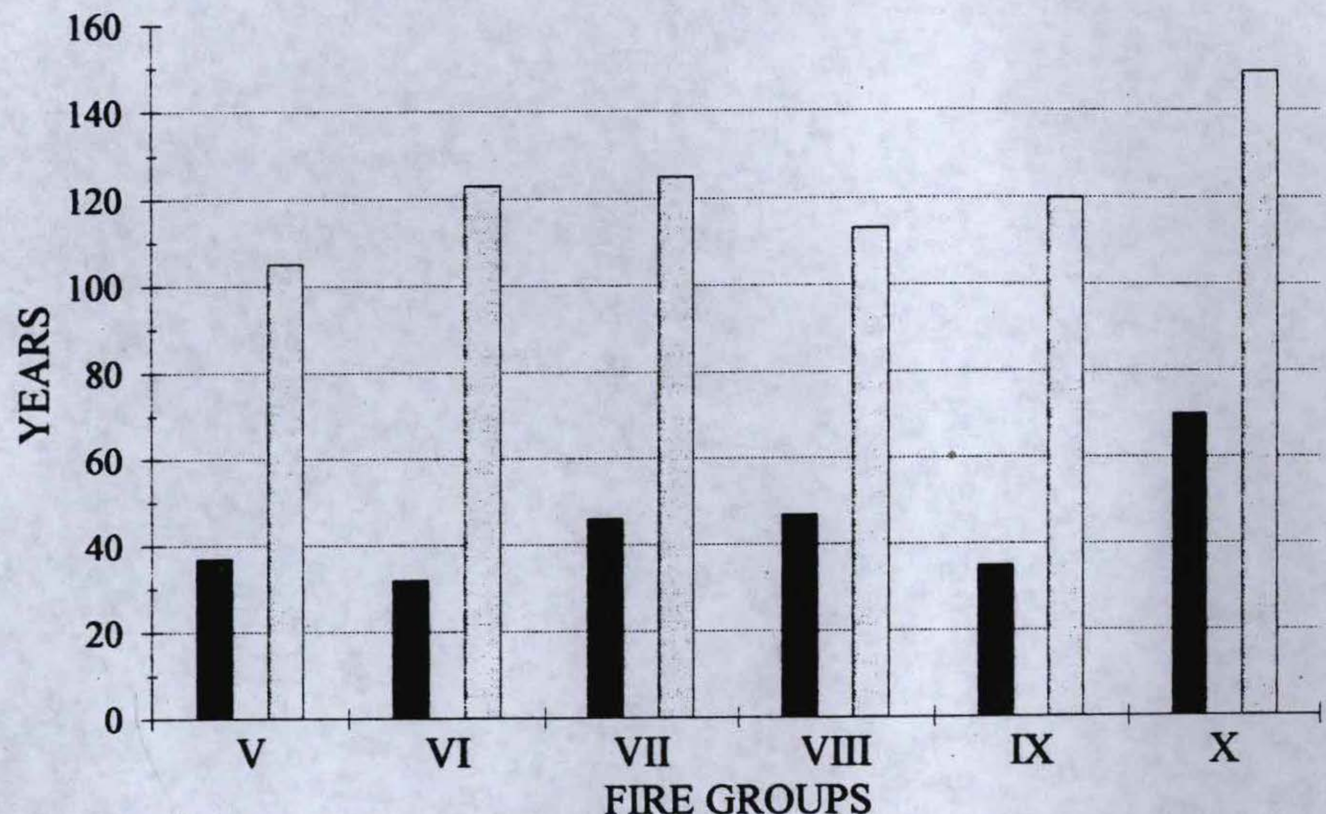


Fig. 9. Historic photo comparisons (Gruell 1983) in southwestern Montana.

Plate 47a (1916) **Fire Group 5: Cool-dry Douglas-fir.** **Elevation 6,600 ft (2 012 m)**

A view north-northwest across the north fork of the Big Hole River toward Battle Mountain. Scene is on the Big Hole Battlefield National Monument. The shrubs behind T. C. Sherril are willow, while the vegetation on the open slope is an association of mountain big sagebrush, perennial grasses, and forbs. Douglas-fir borders the opening at upper right. The two large Douglas-fir trees in the opening were used as cover by a Nez Perce sharpshooter who fired on troopers.

Photograph by Will Cave. Courtesy of University of Montana Archives and Special Collections.

Plate 47b (June 25, 1980) **64 years later**

Willows appear to be more dense and Douglas-fir are invading what was formerly an open slope. The sparse appearance in upper branches of the sniper trees is the result of dieback. Mountain big sagebrush has increased in density. Fire scar evidence in this locality (Pierce 1982; Arno and Gruell 1983) suggests that prior to 1900, wildfire swept these slopes on the average of about every 35 years.

Photograph by G. E. Gruell.

Fig. 9. (cont.)

Plate 62a (1916) Fire Group 6: Moist Douglas-fir. Elevation 6,900 ft (2 104 m)

Looking north across Romy Lake in the Gravelly Range, Beaverhead National Forest. Lake shoreline and flats in distance are covered by large willows. Note young conifers on lower and distant slopes. Young aspen suggest previous disturbance by wildfire.

USGS photograph 201 by D. D. Condit.

Plate 62b (July 8, 1980) 64 years later

Raising of lake level apparently killed willows. On the flats in the distance, willows are smaller than in 1916. Douglas-fir and other conifers have regenerated in the large opening beyond lake. Competition from conifers has resulted in deterioration and die off of aspen on various sites. The opening at right center is a clearcut made during a 1962 timber sale.

Photograph by W. J. Reich.

Fig. 9. (cont.)

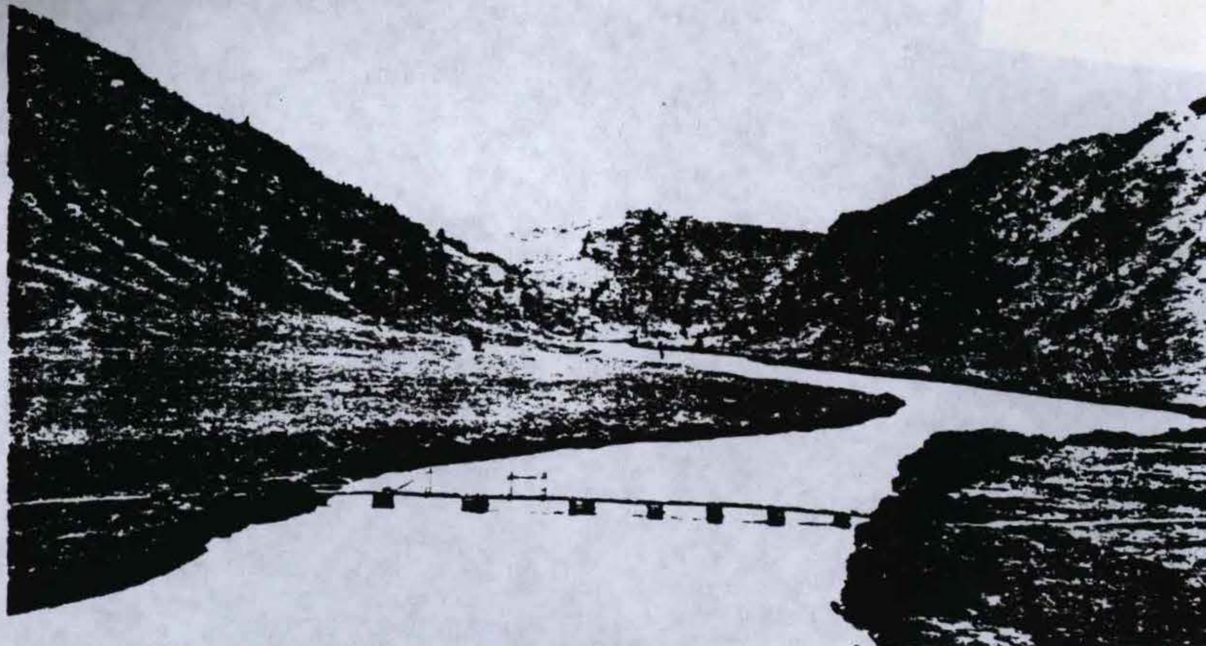


Plate 70a (1871) Mahogany Fire Group. Elevation 4,500 ft (1 372 m).
Looking south-southeast across the Madison River at a point 0.3 miles below present Highway 84 bridge crossing at Beartrap recreational area. Conifers in distance are largely Douglas-fir. Some limber pine and Rocky Mountain juniper are also present. Curlleaf mountain-mahogany are restricted to rocky outcrops.
USGS photograph 911 by W. H. Jackson.

Plate 70b (August 31, 1982) 111 years later
Logging in the latter 1800's and the absence of fire allowed mahogany to proliferate. Note the large stand at right (arrow) that is growing on a site formerly dominated by conifers. Douglas-fir, juniper, and scattered limber pine also regenerated following cutting and are now outcompeting mahogany, skunk-bush, and other vegetation on many sites.
Photography by G. E. Gruell.